TITLE: ADVANCED RESERVOIR CHARACTERIZATION IN THE ANTELOPE SHALE TO ESTABLISH THE VIABILITY OF CO2 ENHANCED OIL RECOVERY IN CALIFORNIA'S MONTEREY FORMATION SILICEOUS SHALES

Cooperative Agreement No.: DE-FC22-95BC14938

Contractor Name and Address: Chevron USA Inc., Production Company (CPDN), 5001 California Avenue, Bakersfield, California 93309

Date of Report: March 31, 1996

Award Date: February 7, 1996

Anticipated Completion Date: June 11, 1998

Government Award for Current Fiscal Year: $ 2, 334,048

Principal Investigator: Stephen C. Smith, CPDN

Project Manager: Edith Allison, Bartlesville Project Office

Reporting Period: January 1, 1996 - March 31, 1996

Objective

The primary objective of this research is to conduct advanced reservoir characterization and modeling studies in the Antelope Shale reservoir. Characterization studies will be used to determine the technical feasibility of implementing a CO_2 enhanced oil recovery project in the Buena Vista Hills field. The Buena Vista Hills pilot CO_2 project will demonstrate the economic viability and widespread applicability of CO_2 flooding in fractured siliceous shales reservoirs of the San Joaquin Valley. The research consists of four primary work processes: Reservoir Matrix and Fluid Characterization; Fracture Characterization; Reservoir Modeling and Simulation; and, CO_2 Pilot Flood and Evaluation. Work done in these areas can be subdivided into two phases or budget periods. The first phase of the project will focus on the application of a variety of advanced reservoir characterization techniques to determine the production characteristics of the Antelope Shale reservoir. Reservoir models based on the results of the characterization work will be used to evaluate how the reservoir will respond to secondary recovery and EOR processes. The second phase of the project will include the implementation and evaluation of an advanced EOR pilot in the West Dome of the Buena Vista Hills field.

Summary of Technical Progress

The project has just gotten underway and this report will summarize the technical work done during pre-award activities. Pre-award technical efforts included: cross-well seismic field trial; downhole video logging of producing wells; and acquisition and installation of state of the art workstation and modeling software.

Cross-well Seismic

A cross-well seismic project was conducted by Tomoseis, Inc. in wells 553 and 554 of the Buena Vista Hills field in September 1995. The objectives of the cross-well project were:

- To acquire and process high-resolution cross-well seismic data to better characterize the Antelope Shale reservoir prior to drilling a CO_2 injection well
- To provide cross-well data for attenuation tomography processing

- To provide high-resolution cross-well reflection sections for reservoir characterization
- To evaluate piezoelectric source technology in the Antelope Shale

The cross-well seismic project at Buena Vista Hills was unsuccessful. Excessive noise levels, as a result of gas entry into the wellbore, were observed in both wells 553-26B and 554-26B. The wellbore must be fluid-filled to couple signals from the formation to the receivers. The noise levels were excessive in all conditions where the receivers were in fluid. In the Buena Vista Hills project, the source was unable to overcome the high noise levels encountered in the wells.

In summary, testing of the piezoelectric source and cross-well seismic acquisition was not possible with the high observed noise levels. Clamped receivers (geophones or accelerometers) may be less susceptible to wellbore noise. Direct comparison of hydrophone and geophones in areas with noise levels as observed, are not available. If fluid and gas flow can be stopped in the logging interval, such as in a cased hole, clamped receivers in an air-filled well should produce much lower noise levels.

Video Logging

Downhole video logs were run on wells 553-26B and 554-26B in October 1995 to determine exactly where oil, gas, and water enter the wellbore. Downhole video logs were used to determine fluid entry because the wells are produced on pump and there was not sufficient room to run production logs in the annulus between tubing and the slotted liner. Furthermore, interpretation of production logs in low-volume producing wells can be extremely subjective and video logging provided the opportunity to obtain more definitive data.

Oil and water entry were observed in the air-filled portion of well 554-26B under both shut-in and flowing conditions. Gas entry was observed in the air-filled part of the borehole during flowing conditions only and in the fluid-filled part of the borehole during both shut-in and flowing conditions. Oil entry was concentrated in a 25 ft thick zone just below "P" point, although evidence for oil entry near the bottom of the well was also observed. The shut-in fluid level was found at mid-perf level and was static. Gas bubbles obscured vision in the fluid-filled part of the borehole.

This evidence suggests that significant crossflow occurs during shut-in. Gas apparently flows out of deeper parts of the reservoir and into lower pressure zones and water flows from shallower, and possibly deeper parts of the reservoir, into lower pressure zones. Gas and fluid exit points into the formation are unknown. Conventional production logs will be run to determine flow rates and exact water and gas entry points.

The fluid level in the 553-26B was above the slotted liner and fluid entry into the wellbore could not be observed. A shallow casing leak with water entry and several holes in the casing were observed, which probably accounts for the high fluid level.

Application of video logging can be improved by determining fluid levels and shut-in surface pressures prior to running video logs. The wells should be shut-in for a day or more before running the log so that the pressure buildup will push the fluid level down to mid-perf level. Gas and water may continue to flow from high pressure zones and may continue to enter low pressure zones. During the logging job a first pass should be made down and then up during shut-in conditions. The camera should then be moved to the top of perforations and the flow line opened enough to begin bleeding off pressure (until hissing is heard). Gradual opening of the well should minimize movement of fines that may obscure visibility and should keep the fluid level from rising too rapidly. The well should then be logged downward until the fluid level is reached. Logging should not continue into the fluid-filled portion of the well unless the fluid was clear during shut-in condition. Once the fluid level has been reached, the flow rate can then be increased and the well logged upward ahead of the advancing fluid level.

Workstation and Modeling Software

The purchase and installation of the Silicon Graphics Inc. workstation is complete. Chevron purchased a 200MHz Indigo2 workstation with 1 MB cache memory, 256 MB RAM memory, Extreme Graphics card, 2 GB system disk, internal 4mm DAT SCSI drive, internal 2X CD-ROM drive, and two 20-inch monitors. An external 9 GB disk drive is on order. The external drive is necessary to install Landmark's StrataModel software for 3D model building and visualization. Chevron is paying for the drive because we anticipate installing other software which will enhance the functionality of the workstation for mapping, cross-section building, and geostatistics. All of these products should work together to provide state-of-the-art geologic computer functionality.

PETC 1325.1
(5-83)

United States Government | Department of Energy

memorandum

Pittsburgh Energy Technology Center

DATE: May 1, 1996

REPLY TO ATTN OF: Document Control Center, MS 921-143

SUBJECT: Review of Technical/Topical Report on Contract/Grant/ Cooperative Agreement No. DE-FC22-95BC14938 with Chevron USA Inc.

TO: Edith Allison, Contracting Officer Representative

The attached technical/topical report has been submitted by the contractor/recipient and requires your review and approval. Review should be completed within 15 calendar days of the date of this memo.

Please provide the contractor/recipient with approval or with notification of changes required prior to approval, and obtain and approve these changes. A copy of your correspondence concerning the report should be provided to the Contract Specialist. Your approval shall be indicated below and provided to the PETC AAD Document Control.

Technical Report for period ending: 03/31/1996

[x] The report has been approved.

[ ] The report must be revised.

[ ] Attached is a copy of my comments that were provided to the contractor/recipient.

[ ] Comments: ______

RECEIVED USDOE/PETC 96 MAY 17 AM 10:09 ACQUISITION & ASSISTANCE DIV.

[signature] 05/15/96

Contracting Officer Representative   Date

bcc:
William R. Mundorf
DE-FC22-95BC14938
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